CO_2 Laser Effects on Root Surfaces in Periodontal Treatment: Case Reports

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Purpose: The purpose of this pilot study was to evaluate periodontal tissue repair after CO_2 laser application in the treatment of severe periodontal defects.

Materials and Methods: Three patients, 2 men and 1 women, age range 37 to 55 years old, were selected for the study. All of the participants in the study were in good general health and presented with at least 1 tooth with a probing depth of 6 to 9 mm, clinical attachment level of 4 mm, and bleeding on probing. At baseline, all patients received full-mouth scaling and root planing, motivation, and oral hygiene instructions. Clinical assessment after cause-related therapy showed the need for additional periodontal treatment. The periodontal surgery procedures were performed with the adjunctive use of a CO_2 laser in defocused pulsed mode at 2 W, with a frequency of 20 Hz and a duty cycle of 6%. The patients were reassessed 12 months after surgery.

Results: All the teeth that received periodontal surgery in conjunction with laser treatment showed significant improvement for all periodontal parameters examined.

Conclusion: CO_2 laser treatment may induce predictable clinical improvements when used as an adjunct to conventional periodontal surgery. More extensive, long-term studies are needed to confirm this hypothesis and to better clarify the effect of laser treatment on periodontal wound healing.

Key words: periodontal disease, periodontal treatment, tooth root, laser therapy.

J Oral Laser Applications 2004; 4: 109-117.

Periodontal disease is characterized by bacterial colonization of root surfaces, progressing to infiltration of the soft tissues of the periodontal pocket[1,2] and also the dentinal tubules.[3,4] Following mechanical root instrumentation, the root surfaces still remain covered by a smear layer rich with contaminated root cementum, bacterial endotoxins, and subgingival plaque.[5] Laser treatment has been proposed for root surface conditioning as adjunctive therapy to mechanical instrumentation to obtain periodontal connective attachment.[6] In vitro analysis has shown that temperature increase on the root surfaces is dependent on the irradiated energy. The wavelength of CO_2 laser is 10.6 µm, placing it thus in the infrared range, and 90% of its energy is absorbed in 0.03 mm of water.[7]

This type of wavelength falls within the specific absorption spectrum for calcium hydroxyapatite: 9.0 to 11.0 µm.[8] Due to this physical property, the CO_2 laser would be effective for use on mineralized tissues such as cementum and dentin surfaces,[9] because of its ability to seal the dentinal tubules, eliminating niches for bacteria.[10] CO_2 laser treatment in defocused, pulsed mode with a low power of 2W combined with mechanical instrumentation constitutes a useful tool to condition the root surface and increase fibroblast attachment to root surfaces.[11]

Using an experimental animal model, some authors observed the efficacy of CO_2 laser treatment in controlling the apical epithelial migration and in increasing the amount of connective tissue attachment.[12] During periodontal open flap surgery the inner surface of the flap was de-epithelialized using the CO_2 laser. This treatment showed a significant decrease of epithelial apical ingrowth during the healing period with respect to non-lased control sites. Moreover, other authors found results consistent with the study reported above on CO_2 laser treatment in limiting junctional epithelium migration and in enhancing connective tissue attachment and cementum repair.[13] These authors reported that examinations held at 10-day intervals during the healing period proved a significantly higher percentage of connective tissue attachment in the test sites (laser treated) than in the control sites (flap debridement only) during the first 30 days.

The purpose of this report was to clinically evaluate the efficacy of CO_2 laser as adjunctive treatment to conventional periodontal surgery in severely compromised teeth.

MATERIALS AND METHODS

Three clinical cases were included in this study. The medical history of the patients was noncontributory; at the time of the study, they were not taking medications nor had they taken any antibiotics in the previous 3 months. They had not received periodontal treatment in the previous 6 months. Periodontal treatment for all clinical cases consisted of scaling, root planing, and oral hygiene instructions. Four weeks after completion of the nonsurgical treatment, a re-evaluation was performed and the surgical procedures were planned. Following a thorough explanation, the patients consented to undergo periodontal surgery with the adjunctive use of CO_2 laser on root surfaces.

Clinical Evaluation

The patients underwent a clinical and radiographical examination prior to the surgical procedures. The periodontal parameters registered were as follows: presence of plaque (PI),[14] bleeding on probing,[15] probing depth (PD) at 6 sites for each tooth, clinical attachment levels (CAL) at 6 sites for each tooth, and the apicocoronal dimension of keratinized tissue at the buccal and lingual side of each tooth. Measurements were taken manually using a Michigan periodontal probe and rounded to the nearest millimeter.

The same periodontal parameters were registered at the follow-up visits. Periapical radiographic examination was carried out before surgery and at the follow-up visits.

Surgical Procedures

The same surgical procedures were used for each patient. Briefly, a full-thickness flap was raised and granulation tissue removed. Subsequently, the CO_2 laser was used (El.En, Florence, Italy) to treat the exposed root surfaces in defocused pulsed mode with 2W of power, 20 Hz frequency, and a duty cycle of 6%. The duty cycle is defined as laser pulse duration divided by the whole period, and it has a range of 2% to 40%.

The soft tissues were treated in defocused pulsed mode with 13 W of power, with 40 Hz frequency and a duty cycle of 40%. After laser treatment, all the root surfaces underwent ultrasonic instrumentation (Odontoson M, Goof, Denmark). The full-thickness flap was sutured with 4-0 silk (Ethicon, Somerville, NJ, USA), and the wound was covered by a periodontal dressing (Coe-Pak, G.C. America, Chicago, IL, USA). The sutures were removed 7 days postoperatively.

Postoperative drug prescription consisted of chlorhexidine mouthwash (Dentosan, Parke-Davis, Courbevoie Cedex, France) twice daily for 3 weeks and analgesic medications (Ibuprofen 800 mg every 8 h) taken as necessary.

CLINICAL CASES

Case 1

The patient was a 45-year-old male who consulted our Department because of increased tooth mobility and recurrent abscesses around the mandibular incisors. The patient (a nonsmoker) reported good general health conditions and no medications taken in the last 3 months. The periodontal treatment plan consisted of scaling, root planing, and oral hygiene instructions. Six weeks after completion of cause-related therapy, the patient again underwent periodontal evaluation, showing very high PD and CAL values, and bleeding on probing at all examined sites of the mandibular incisors

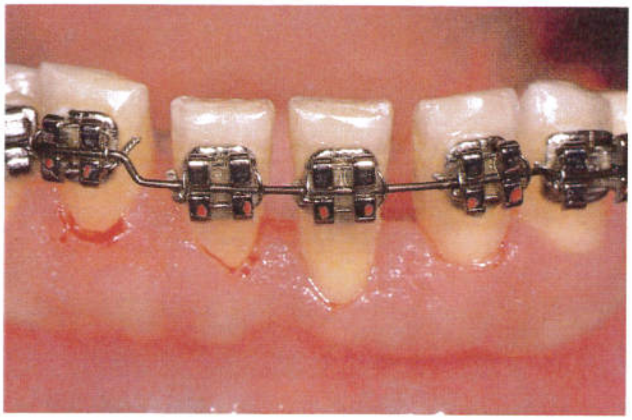

Fig 1 Presurgical clinical view of the mandibular incisors.

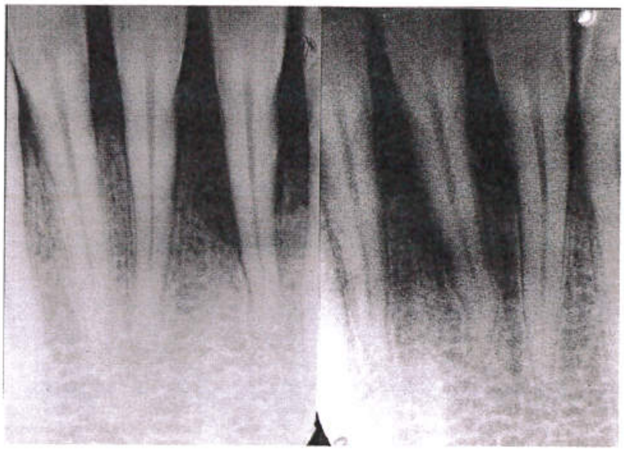

Fig 2 Preoperative radiographic examination of the mandibular incisors.

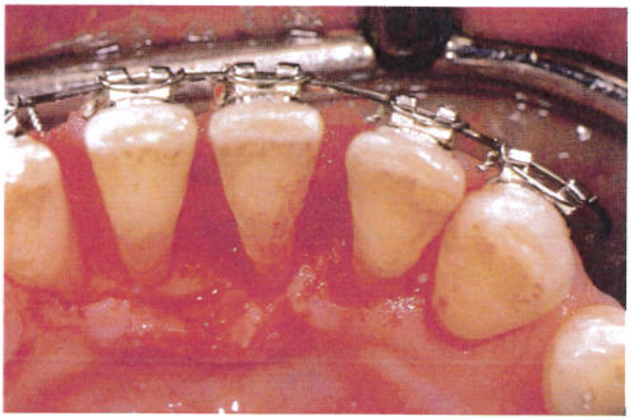

Fig 3 Gingival flap reflection showed a large bone defect at the level of right central mandibular incisor.

Fig 4a

Figs 4 a and 4b Root surfaces after CO_2 laser treatment during surgery.

(Figs 1 and 2). The surgical procedure was planned and the patient was asked and consented to undergo periodontal surgery with the laser used as an adjunctive tool. The surgical procedure was performed as described above (Figs 3 and 4). After surgical flap reflection and CO_2 laser treatment, the root surfaces were instrumented using an ultrasonic device (Fig 5). The flap was sutured at the original levels using 4-0 silk, a periodontal dressing was placed over the area, oral analgesics (Ibuprofen 800 mg every 8 h as necessary) and a 0.12% chlorhexidine gluconate mouthwash were prescribed. Dressing and silk sutures were removed 1 week postoperatively. The patient was examined weekly up to 1 month after surgery and was subsequently included in a personally tailored recall schedule for supportive periodontal maintenance.

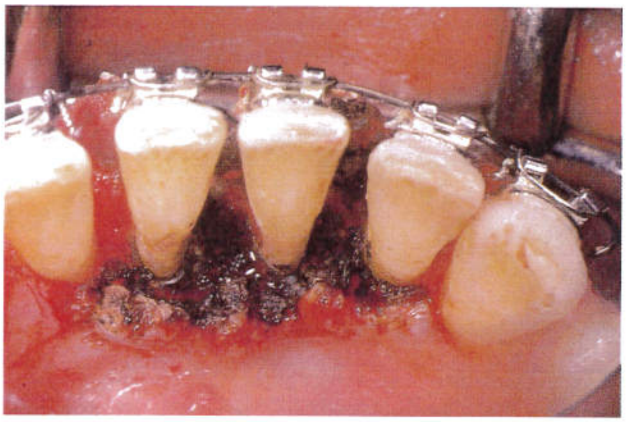

Fig 4b

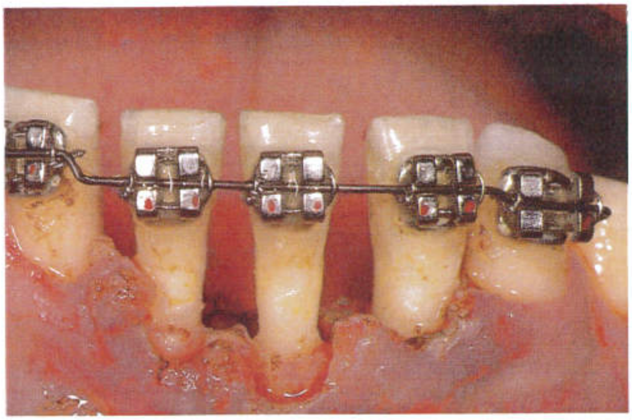

Fig 5 Root surfaces after ultrasonic instrumentation.

Fig 6 Clinical aspect 36 months after surgical treatment.

Fig 7 Radiograph examination 36 months after surgical treatment.

Fig 8 Clinical aspect 8 years after surgical treatment.

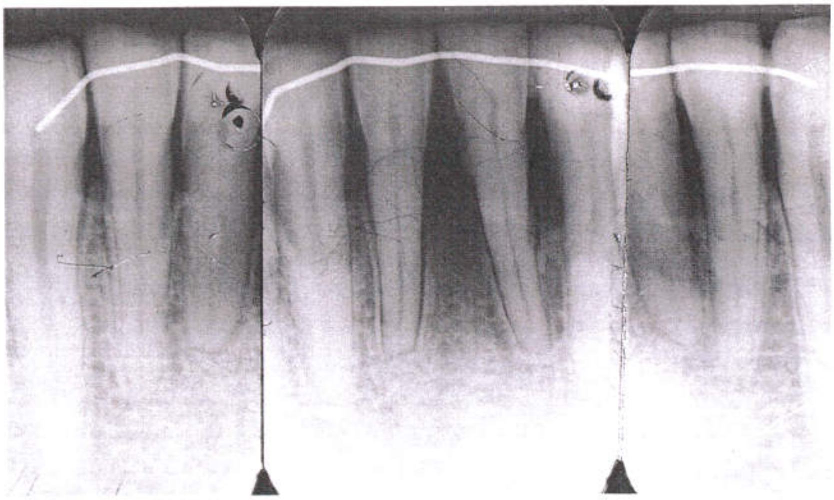

Fig 9 Radiograph examination 8 years after surgical treatment.

Fig 10 Presurgical clinical view of the second premolar.

Fig 11 Preoperative radiographic examination.

At the 36-month follow-up, the patient showed a mean probing depth reduction of 4 mm, and a clinical attachment gain of 5 mm (Figs 6 and 7).

Eight years after treatment, both clinical and radiographic examinations confirmed the good clinical status of periodontal tissues (Figs 8 and 9).

Case 2

A 54-year-old male presented with a periodontal defect at the level of a maxillary premolar. The patient complained of recurrent gingival inflammation and mobility of the tooth. Chronic periodontitis was diagnosed and the patient underwent cause-related therapy consisting of oral hygiene instruction, subgingival scaling, and root planing. After initial therapy, clinical and radiographic examinations were assessed (Figs 10 and 11). The maxillary premolar showed a bone defect with a PD of 12 mm and a CAL of 15 mm, confirming the suitability of the site for periodontal surgery. A complete explanation was given to and informed consent was obtained from the patient. After local anesthesia, a full-thickness flap by sulcular and vertical incisions was reflected. The bone defect was debrided and root surfaces were treated with CO_2 laser and an ultrasonic device as described in the materials and methods section (Figs 12 and 13). The full-thickness flap was advanced to a coronal position and sutured using a 4-0 silk suture (Fig 14). A periodontal dressing was placed over the surgical area, oral analgesics (Ibuprofen 800 mg every 8 h as necessary) and a 0.12% chlorhexidine gluconate mouthwash were prescribed.

The dressing and silk sutures were removed 1 week postoperatively. The patient was kept under strict oral hygiene monitoring every week for 2 months.

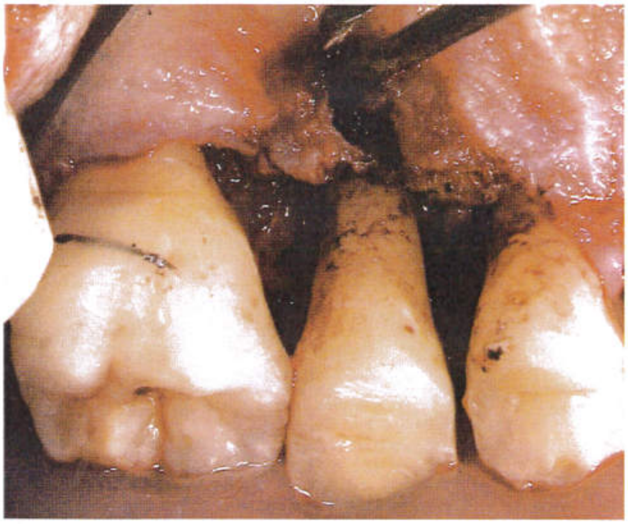

Fig 12 Root surfaces after CO_2 laser treatment during surgery.

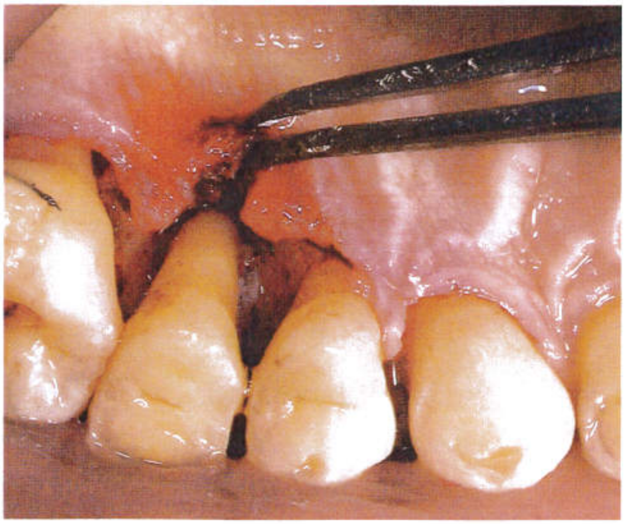

Fig 13 Root surfaces after ultrasonic instrumentation.

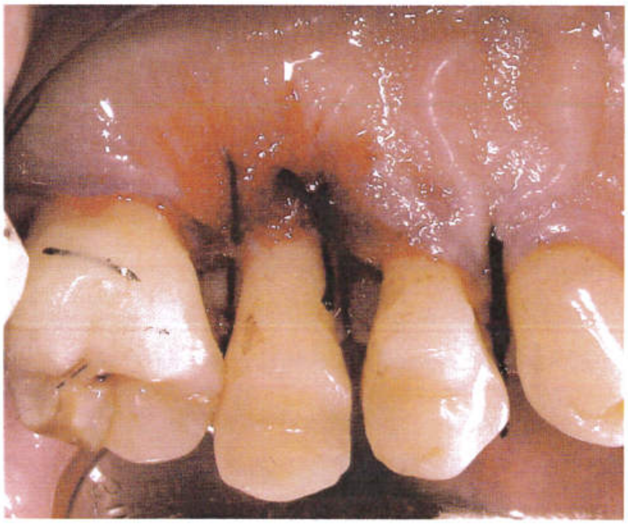

Fig 14 The full-thickness flap was advanced to a coronal position and sutured using a 4-0 silk suture.

One year after surgery, the clinical examination showed good periodontal healing, with a PD reduction of 4 mm and clinical attachment gain of 4 mm. The radiographic examination confirmed the good clinical condition and filling in of the bone defect (Figs 15 and 16).

Case 3

A 39-year-old female presented to our office with a chief complaint of inflammation, bleeding, and mobility at the level of the first mandibular left molar (Fig 17). The patient was diagnosed as having chronic periodontitis. After oral hygiene instructions, subgingival scaling, and root planing, the decision was made to perform flap surgery with the aid of the CO_2 laser at the level of the first maxillary right molar. A complete explanation was given and informed consent was obtained from the patient. A full-thickness flap was raised, and the root surfaces were treated with CO_2 laser and the ultrasonic device as reported above.

The full-thickness flap was advanced to a coronal position and sutured using a 4-0 silk suture. A periodontal dressing was placed over the surgical area, oral analgesics (Ibuprofen 800 mg every 8 h as necessary) and a

Fig 15 Clinical aspect 12 months after surgical treatment.

Fig 16 Radiographic examination 1 year after surgical treatment.

Fig 17 Preoperative radiographic examination.

Fig 18 Radiographic examination 1 year after surgical treatment.

0.12% chlorhexidine gluconate mouthwash were prescribed.

The dressing and silk sutures were removed 1 week postoperatively. The patient was included in a personally tailored recall schedule for supportive periodontal maintenance. The follow-up visit 1 year after surgery showed good periodontal healing with a probing depth reduction of 4 mm and a clinical attachment gain of 3 mm. The periapical radiographic examination showed bone repair (Fig 18).

DISCUSSION

The aim of this study was to analyze the effect of CO_2 laser treatment used as an adjunctive tool to promote periodontal healing when used in combination with periodontal surgery. The rationale for this hypothesis was derived from the ability of CO_2 laser treatment to promote periodontal healing on root surfaces.

Some studies have shown that temperature increase on root surfaces due to laser treatment is strictly associated with the energy delivered.[16] These authors studied the effects of a CO_2 laser at two power levels and six exposure times on root dentin. The findings from the study mentioned above revealed damage to the root surface, such as cratering and fissures. Moreover, the authors observed the melting of the dentin and the partial sealing of the tubules at a deeper level, concluding that with the increase of the exposure time, the craters quickly expand causing severe changes in the tooth structures.[16]

The temperature increase in the depths of the irradiated tissue (0.5 to 1 mm from the impact point) was moderate because of the water absorption potential of the radiation. Energies from 2 to 4.5 J could produce a surface temperature increase that provides biocompatible conditioning.[6] The laser treatment with 3W of power and 1 second of irradiation time might completely remove the smear layer present on root surfaces of teeth after root planing, with minimal change in the diameter of the dentinal tubules.[9]

More recently, in an in vitro study, the CO_2 laser used in pulsed mode with a non-focused beam 4 mm in diameter created flat, smooth root surfaces upon which the smear layer was removed and the dentinal tubules were sealed, with no damage to the root surfaces.[17] On the other hand, CO_2 laser in continuous mode with a focused beam of 0.8 mm severely damaged dentin surfaces, creating craters and fissures. Indeed, different studies have pointed out the damage caused by a CO_2 laser beam used in focused mode on root dentin surface.[18-23] Both laser treatment modalities – pulsed non-focused mode and continuous focused mode – induced several changes on the treated root surfaces. The morphological modifications obtained with the non-focused pulsed mode resulted in smooth surfaces that were highly biocompatible. This was shown in an in vitro study[11] where 30 single-rooted human teeth were extracted because of advanced periodontal disease and treated with CO_2 laser to analyze its effects on root surfaces. A total of 60 specimens, obtained from all selected teeth, were randomly assigned to 3 groups: 1) control group (untreated); 2) scaling and root planing (SRP) group; or 3) laser (CO_2 non-focused, pulsed) and ultrasonically treated group. Subsequently, all the specimens were tested for fibroblast adhesion. The control group showed the lowest number of attached cells, and the laser/ultrasonic group showed the highest number of attached fibroblasts. The laser-treated and scaled root specimens did not show any damage or morphological alteration of the root surfaces. CO_2 laser treatment in non-focused pulsed mode with a power of 2W combined with mechanical instrumentation constitutes a useful tool to condition the root surface and increase fibroblast attachment to root surfaces.[11]

In a study on experimental animals,[24] the effect of CO_2 laser treatment on periodontally involved root surfaces was compared with SRP alone and with SRP plus guided tissue regeneration (GTR). Quadrants were randomly assigned to a) CO_2 laser treatment (laser), b) GTR using Gore-Tex membranes, and c) scaling and root planing (SC/RP). A CO_2 laser beam (El.En, Florence, Italy) was applied to the root surfaces in non-focused pulsed mode at 2W, 1 Hz, and a duty cycle of 6%, and on periodontal soft tissues at 13W, 40 Hz, and a duty cycle of 40%. The laser group showed new attachment formation averaging 1.9 mm (± 0.5), whereas GTR and SRP groups showed 0.2 mm (± 0.4) and 0.2 mm (± 0.5) respectively. The differences between the laser group and both GTR and SRP groups were statistically significant ($p < 0.005$).

The same histological results were reported in humans by Israel in an vivo study.[13] Six mandibular incisors in two patients were selected. The teeth were splinted together, open flap debridement was performed on all teeth after initial therapy, a notch was placed on the roots at the height of the crest of the alveolar bone, and the flaps were sutured in place. The test side received controlled de-epithelialization of the outer (oral) gingiva with the carbon dioxide laser, and the inner gingival flap was treated with the laser in defocused mode but with different parameters, as described. The de-epithelialization was repeated on the test side at 10, 20, and 30 days postoperatively. The control side received an open flap. At 90 days, block sections were taken from the patient and processed for histological analysis, which showed the notch completely filled with connective tissue and a limited repaired cementum in the laser-treated teeth. In all control teeth, the junctional epithelium extended the entire length of the root to the base of the reference notch.

Rossman et al[12] used CO_2 laser with different mode settings to treat periodontal soft tissues in periodontal disease. In a study on monkeys with experimentally induced periodontal disease, the authors removed oral epithelium from soft tissues by CO_2 laser irradiation. They observed less epithelium and more connective tissue attachment on the experimental side compared with control. One year after treatment, the pocket depth measurements were less than 3 mm with an evident pocket depth reduction compared to the baseline value of 6 mm.

The gain of clinical attachment level after CO_2 laser treatment may also be due to minimal contraction in CO_2 laser wounds because of the lack of myofibroblasts, the cells responsible for wound contraction. In fact, in a histological study in rats, Zeinoun et al[25] observed the maximum amount of myofibroblasts was almost three times higher in scalpel than in laser excisions. The peak value was reached at 4 days in laser and at 3 days in scalpel wounds. The increase reverted to normal levels at 14 days in laser and at 6 days in scalpel wounds. Myofibroblasts appeared and disappeared more slowly in laser wounds. There were clearly fewer myofibroblasts in CO_2-laser than in corresponding scalpel excisions, known to heal by contraction. The lack of contractile myofibroblasts, therefore, is suggested as the reason for the minimal degree of contraction in CO_2 laser excision wounds.

CONCLUSION

CO_2 laser treatment may induce predictable clinical improvements when used as an adjunct to conventional periodontal surgery. More extensive, long-term studies are needed to confirm this hypothesis and to better clarify the effect of laser treatment on periodontal wound healing.

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